



## Original Communication

## Resuscitation and conjunctival petechial hemorrhages

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## ABSTRACT

In recent years, cardiopulmonary resuscitation (CPR) has been discussed as a cause of petechial hemorrhage in eyelids and conjunctivae, which could be of substantial significance to forensic expertises in cases of suspected strangulation. In the reported series or case observations, the combination of CPR and petechiae seemed to be sufficient to explain such a causal connection. Nearly all presented cases were victims for which the mechanisms resulting in death were themselves well-known causes explaining the development of such petechiae; and said mechanisms can frequently be observed in victims that did not receive CPR. An earlier, also retrospective, analysis of a series of forensic autopsies did not confirm CPR as a significant cause of conjunctival petechiae. Now we present the result of a prospective examination of 196 resuscitations of adult patients with separate assessment of petechiae being present even prior to resuscitation. Petechiae were present in 12 cases – but in eight of them prior to resuscitation already. Three other persons with petechiae found only after CPR were in the group of successfully resuscitated persons and exhibited petechiae hours after CPR during therapy in intensive care units – during a phase of ongoing cardiac insufficiency, which obviously caused them. The only case with petechiae observed neither immediately prior to nor after unsuccessful resuscitation, but during a follow-up examination one day later, needs to be discussed. It is not interpreted as reliable evidence for the causality of CPR though. Our interpretation of reports in literature as well as our experiences confirm the absence of actual proof of petechiae being generated by CPR and in the presence of generally significant doubts of this relation.

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## 1. Introduction

Petechial hemorrhage in eyelids and conjunctivae, resulting from venous congestion of the upper body/head, are a common finding in forensic autopsy materials, especially in deaths due to strangulation. Although quite frequent in these cases and interpreted as significant indicators for type, degree and duration of strangulation, they are not specific for this mechanism and can be found in a variety of traumatic and natural causes of death.<sup>1–6</sup> The accepted possibility of artificial petechiae has long been restricted to the knowledge of post-mortem development with a prone or head-down position of the corpse; reports presenting extensive studies or common knowledge concerning the occurrence of petechiae did not include CPR as an important factor.

In the last two decades, another mechanism – cardiopulmonary resuscitation (CPR) – has attracted notice, which could be of serious significance for forensic expertises; CPR is an increasing factor in post-mortem examinations, even in cases of homicides.

There is some similarity to retinal bleedings in cases of suspected shaken baby syndrome, and a marked number of publications present the results of such studies – with contrary results.

However, there has to date been relatively little discussion of CPR as a possible mechanism causing petechiae – as opposed to the frequency of CPR – and it is generally restricted to observations of a few cases or to cursory statements in larger series (“CPR also seems to enhance the development and the appearance of petechiae”<sup>6</sup>). There is no intense discussion of the difference between “mere observation” (petechiae and CPR present together) and causation (petechiae caused by CPR), or of the question if the petechiae observed were present prior to CPR already. Surprisingly, the extensive anaesthetic literature does not include any reports of petechiae viewed as a result of CPR, and there is no prospective forensic investigation.

Factors influencing the key development of petechiae are a field of special interest in our institution.<sup>3,7–9</sup> And we have added a prospective clinical-forensic investigation as findings reported earlier<sup>10</sup> in our documentation did not really support the theory of petechiae being caused by CPR.

## 2. Existing topic-owned experience in our institution

An earlier retrospective study<sup>3,10</sup> analysed the presence of petechiae in 473 autopsies performed by one investigator (series 1), herein excluding strangulation, violent asphyxiation, corpses

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altered by decomposition, found in a prone position or with severe burns (on the head). The study evaluated the presence of petechiae depending on CPR, causes of death, age, sex, body constitution, heart weight and other factors. An additional analysis assessed these relations in 181 cardiac deaths examined in our institute (from 1988 to 1993; series 2).

In brief summary of the essential results including additional data assessment, we are able to present following results: petechiae were present in 13.3%, strongly depending on the causes of death (up to 22% in cardiac death).

In series 1, the rate of petechiae in victims with CPR was higher than in the non-CPR group (19% vs. 11%). However, further analysis related the frequency of petechiae to age (predominantly present in middle age; Fig. 1), body constitution (10% in slim, 35% in obese patients; Fig. 2) and heart weight. Additionally, the difference in occurrence of petechiae in the CPR/non-CPR groups was nearly limited to cardiac deaths (where petechiae are relatively frequent in general) and not present in most other causes of death. In series 2 (181 cardiac deaths), the difference in petechial frequency between CPR and non-CPR cases decreased and was restricted to coronary death/myocardial infarction (Fig. 3).

### 3. Material and methods of the actual study

The site of our study is an area in the Dahme-Spreewald territory in Brandenburg, Germany, with an approx. population of 160,000. General emergency teams are based in one of seven stations, the three ambulances with emergency physicians in one of the hospitals. CPR and documentation were performed by 10 different physicians (consultants of surgery, internal medicine and anaesthesia); 112 of the victims were subsequently seen by one of us (R.J.) within 24 h. To assist uniform diagnosis, all participating physicians were provided with a check-list, including photographs of petechiae in eyelids and conjunctivae (see Fig. 4). Included were all CPR treatments (only cases of cardiac arrest outside of hospitals) performed on adults, initiated and carried out by emergency physicians, with the exception of all violent deaths (such as strangulation, traffic accidents, or trauma from other causes) in the period October 2004 to April 2007. Cases with non-medical resuscitation were excluded. Examination of the orbital region prior to resuscitation included a (quick) inspection of eyelids and conjunctivae as part of the usual emergency diagnosis; the existence of extraorbital petechiae could not be checked at that time. The second examination after interruption of CPR – as well as

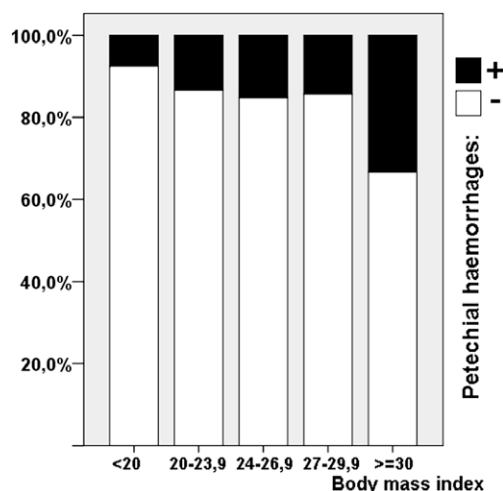


Fig. 2. Frequency of petechial bleedings depending on body mass (series 1).

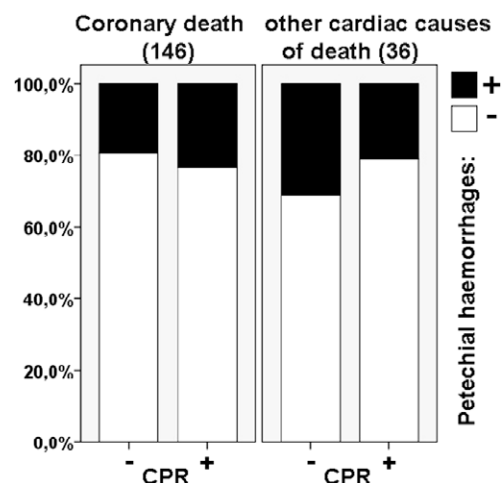


Fig. 3. Presence of orbital petechiae in an additional retrospective analysis of 182 autopsies (series 2). CPR–: no resuscitation; CPR+: resuscitation performed but unsuccessful.

the subsequent third inspection by R.J. – could be carried out without temporal pressure and with more detail. Altogether, petechiae were found in the orbital region only.

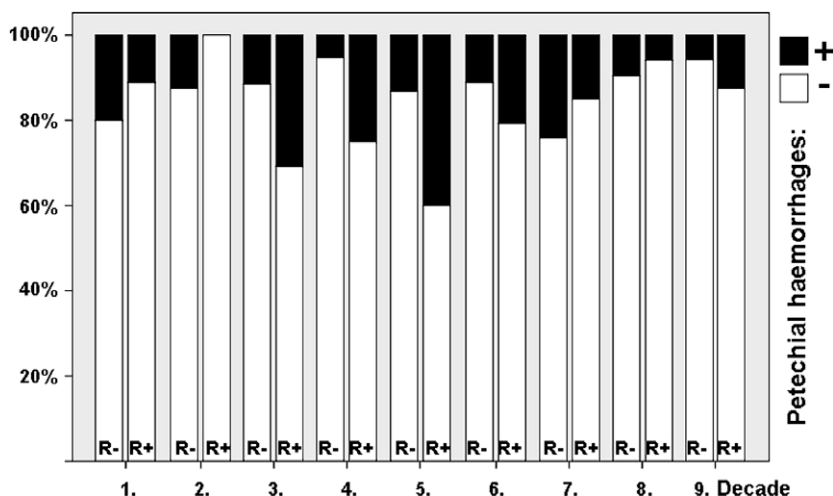


Fig. 1. Presence of orbital petechiae – related to age and resuscitation – in 473 forensic autopsies (series 1). R+: resuscitation performed; R–: no resuscitation. For detailed information, see [3,10].



**Fig. 4.** Exemplary photographs of petechiae in eyelids and conjunctivae given to participating physicians along with the check-lists.

111 of these 196 victims were female and 86 male. The vast majority were old (56–70 years,  $n = 58$ ) or very old ( $>70$  years,  $n = 112$ ). 61 persons had a “normal” constitution, 44 were slim and 79 adipose.

CPR was unsuccessful in 131 and successful in 65 cases, 31 of which died within 24 h and 34 survived (longer). Presumable causes of death (diagnosed by the emergency physician; autopsies were generally not performed): cardiac death – 94 (coronary disease, infarction, sudden death – 60; arrhythmia – 34); pulmonary edema due to cardiac insufficiency – 20; pulmonary insufficiency – 16; pulmonary thromboembolism – 11; cerebral infarction – 12. In 23 cases, “senility” was presumed to have resulted in death; the remaining 20 deaths were caused by various diseases.

#### 4. Results

The intervals between the alarm and the start of CPR ranged between 3 and 26 min (average: 12), the length of CPR differed from 5 to 90 min (average: 29; less than 20 min: 40%; 20–40 min: 40%; longer: 20%). Petechiae were generally found in 12 of the 196 persons examined (6%); all 12 were adipose. CPR in these cases lasted between 20 and 40 min; defibrillation was not performed in any of them. The frequency of petechiae differed between middle and old age groups: petechiae were present in 3 out of 23 (13%) persons younger than 55, in 4 out of 54 (7%) in the 56–70 age group and in 5 out of 107 (5%) older persons.

In 9 of the 12 cases, CPR was futile; in eight of them, petechiae were documented immediately after unsuccessful termination of CPR. In all eight cases, the presence of petechiae was documented prior to CPR so generation of them by CPR is thus precluded. Six patients were female (except one that was older than 70) and two male (32 and 70 years of age). Cardiac insufficiency was established in two cases and pulmonary diseases in four of them with both diseases the obvious cause of death; in two cases, the alarm was raised because of acute cessation of breathing with no further anamnesis available.

Three victims could be resuscitated successfully. None of them had petechiae immediately before or after CPR; they were present

only in the second examination of the live patients in the hospital (intensive care unit) several hours later: 57-year old man, a 61-year old and a 90-year old woman; all obese; all suffering from decompensated cardiac insufficiency.

Altogether only one case remained, in which the petechiae seen in the second examination of the corpse were not documented prior to CPR – but also not directly following CPR. In this case the alarm was raised because of the acute asphyxia of a 54-years old woman with known cardiac insufficiency. CPR was unsuccessful after 40 min.

#### 5. Discussion

Clinical literature includes many studies presenting complications of CPR – predominantly to help understand the causes of such adverse side effects and to find methods to avoid them. Most of these reports concern chest and abdominal (liver) injuries, which can entail significant danger to patients if CPR is successful. External findings in the face and neck and injuries of the internal neck structures originating from CPR but resembling those of asphyxiation and strangulation have been repeatedly studied from a forensic point of view<sup>11–13</sup> and are sometimes difficult to definitively link to one of these causes.

Petechial hemorrhage of eyelids and conjunctivae generally explained as a result of congestion of the upper body (respectively of the head): “congestion bleedings” due to abnormally high intravascular pressure, presumably in combination with hypoxic effects. These mechanisms suggest comparable consequences in cases of cardiopulmonary resuscitation; such conclusions presented in the literature at first seem to be reasonable.

CPR is intended to generate circulation and achieves this through heart compression and/or the “thoracic pump”. Any mechanical chest compression (especially in conjunction with pressure respiration) leads to an increase of intrathoracic pressure which is transmitted to all intrathoracic vessels. However, sufficient blocking against the transmission of this pressure into the extrathoracic venous circulation is essential in order to generate artificial circulation. Apart from the jugular pathway, venous pressure can be transmitted into the head area via the paravertebral venous plexus; this does not seem to be very effective though. Blocking of the jugular pathway in part achieved through adequate closure of the large cervical veins by venous valves.<sup>14–18</sup> Adults have an average jugular vein pressure of 21 mm Hg during resuscitation (max. almost 40 mm Hg)<sup>15</sup> – generally not enough to cause vascular rupture. This protective function may break down under pathological conditions, especially if central venous pressure<sup>14</sup> is increased. The jugular vein valves prevent venous pressure expansion into the cervical region in the presence of anatomically and functionally intact valves and the absence of chronic, severe right ventricular insufficiency.

Similar (and to this day controversial) discussions concern the production of retinal hemorrhages by CPR, especially in cases of suspected child abuse. But even though the essential question as well as the mechanisms blamed are identical, there are significant differences (affected age groups, localization of the finding).

Some essentials of the few publications addressing a correlation between CPR and facial petechiae are summarized in Table 1. All reports confirming causality can be attributed to one of the following types: (a) petechiae after CPR seen in causes of death in which frequent development of petechiae is common irrespectively of CPR; (b) scant information for cases which does not allow for critical examination of the conclusions; (c) only cursory statements without presented material.

In our prospective study investigating the presence of petechial hemorrhages in eyelids or conjunctivae prior to and soon after car-

**Table 1**

References explicit addressing a (possible) relation between cardiopulmonary resuscitation (CPR) and facial petechial hemorrhages.

Authors	N (investigated cases)	Petechiae due to resuscitation?	Causes of death with wellknown presence of petechiae, irrespectively of resuscitation	Special discussion of CPR causing petechiae resp. differential diagnosis?
Härm and Rajs <sup>11</sup>	General: ca. 450, special: 21	–	–	CPR does not cause petechiae
Hood et al. <sup>19</sup>	4	4	4 (Cardiac death, epilepsy, gunshot injury of the head)	No
Leadbeatter and Knight <sup>12</sup>	2	2	No detailed information	Petechiae “were considered to be secondary to CPR” “CPR may enhance the development of petechiae”
Fujiwara et al. <sup>20</sup>	46 Cases with petechiae from causes other than asphyxia	Generally: yes, but not specifically reported; N of CPR unknown	All	
Raven et al. <sup>13</sup>	50	13	Included without classification concerning pet: cardiac death: 30%, blunt injury: 32%	“Petechiae are best explained by CPR”
Hashimoto and Moriya <sup>21</sup>	2	2	1 Case not assessable because of scanty reported details; 1 case: fire victim	No comment: 1 case with CPR 18 days before death and questionable again – final CPR?
Hashimoto et al. <sup>22</sup>	1	0	–	“Petechiae can occur as a result of CPR” “is rare but certainly occurs”

diopulmonary resuscitation, petechiae were found in 12 of 196 cases of non-traumatic death. The emergency physicians (with practical CPR experience) were introduced to the objective and could include this quick check in their necessary examination of the patient's condition without risking therapeutic delay.

In 8 of the 12 positive cases, petechiae were present prior to CPR – excluding it as a causative factor of their development. Three surviving patients exhibited petechial hemorrhages hours after CPR – they were treated in intensive care units because of cardiac insufficiency continuing after successful CPR. Their clinical condition alone may explain signs of upper congestion (congestive hemorrhages), and the absence of petechiae shortly after CPR is an additional argument against a causative relation.

The complete series includes only one case requiring further discussion with petechiae (of low intensity) found only the day after unsuccessful CPR during the re-examination of the victim in the funeral home. Unfortunately, an absolutely certain explanation cannot be offered. One might consider the period of prone position of the corpse (e.g. during transport) a theoretical cause; however, we were unable to obtain reliable information of the existence or definite absence of such a position – but it is generally unusual when storing or transporting corpses. Another possibility may be “insignificant” findings being missed under difficult conditions (insufficient light?) by the emergency physician.

In more than half of our cases, patients were examined a second time by another physician several hours later without different findings, except in that single case. Development of petechiae (respectively obtaining a clear visibleness) in a short period (minutes) after the event – especially in cases with immediate circulatory arrest – can be discussed. However, detailed observations concerning the actual early development of petechiae are not available in the literature.

A second significant aspect is the presence of petechiae after CPR predominantly in causes of death in which the development of petechiae is sufficiently explained by the pathophysiology of the actual collapse. This can be interpreted as CPR being an additional factor leading to clearly visible petechiae: the primary cause for petechiae depends on the type of death agony, and if ruptured vessels lead to visible petechiae depends on the rapidity of the complete arrest of circulation. In cases in which this period was too short, CPR with artificial circulation can make already existing damage, respectively microscopically small first signs of extravasations (more) visible.

Our experiences as well as our interpretation of present reports should not be viewed as a definitive rejection of the possibility of

CPR producing petechiae. However, there is no convincing evidence of this mechanism to date, and there are serious arguments to the contrary. CPR should not simply be accepted as the decisive cause of petechiae when investigating actual victims with suspicious neck findings and petechial hemorrhages who had CPR performed on them.

### Conflict of Interest

None declared.

### Funding

None declared.

### Ethical Approval

None declared.

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